CLAIMS

We claim:

1. A scanning evanescent microwave microscope, comprising:

a scanned evanescent microwave element comprising a resonating cavity having an aperture in an electrically conducting endwall and having a center conducting element comprising a tip that extends through the aperture beyond the endwall to form said tip;

frequency measuring means electrically coupled to said tip, for measuring an initial and a final resonant frequency of the resonating cavity, called a frequency shift;

energy measuring means electrically coupled to said resonating cavity for measuring an initial and final ratio of electromagnetic energy dissipated and stored in said resonating cavity, called a Q shift;

a computing element operative to calculate a dieclectric constant and a loss tangent for a material placed near said tip in response to said measured frequency shift and Q shift; and

means for holding said material relative to said tip, said holding means being controlled by a stepping motor having nanometer stability.

2. The scanning evanescent microwave microscope of claim 1, wherein the scanned evanescent microwave element is a scanned evanescent microwave probe.

3. The scanning evanescent microwave microscope of claim 1, further including a feedback element for controlling the distance between the tip and the material.

4. The scanning evanescent microwave microscope of claim 3, wherein said feedback element controls tip-sample distance and its relation to dielectric constant according to the following model equation:

$$C_r = 4\pi\varepsilon_0 R \frac{\ln(1-b)/b+1}{\exp\{G(\varepsilon)[\ln a' - x_0(\varepsilon)]\}+1}$$

5. A method of regulating the distance between a tip of a scanning evanescent electromagnetic wave microscope and a conducting sample being scanned comprising,

a) selecting a preferred distance, g_p, between said tip and sample;

b) determining a reference resonant frequency f_0 of said tip by:

locating said tip far enough away from said sample material that it is not influenced by said sample;

sweeping a frequency range;

plotting frequency versus power;

fitting a curve to find the maximum frequency, called f_0 ;

c) determining Q_0 by dividing f_0 by the frequency difference at two half power amplitude points;

d) calibrating the geometric factors C and R_0 in equations 1 and 24 by measuring and fitting the frequency and quality factors as functions of a gap distance, g, between the probe tip and a reference sample of known conductivity;

e) measuring the resonant frequency and obtaining the absolute difference between it and the reference frequency;

f) calculating the change in gap distance required to return the gap distance to g_p;

g) electromechanically adjusting the distance between the probe tip and the sample being scanned to equal g_p; and

h) repeating steps e) through g) at a set interval period until the scanning process is complete.

6. A method of regulating a distance between a probe tip of a scanning evanescent electromagnetic wave microscope and a dielectric sample being scanned comprising,

a) selecting a preferred distance, g_p, between the tip and sample;

b) determining a reference resonant frequency f_0 of the probe by

locating the probe far enough away from the sample material that it

is not influenced by the sample;

sweeping a frequency range;

plotting frequency versus power;

fitting a curve to find the maximum frequency, called f_0 ;

c) determining Q_0 by dividing f_0 by the frequency difference at two half power amplitude points;

d) calculating the coefficient c from the equation $c = \frac{A_0 f_0}{Q_0}$

where A_0 is the power at f_0;

e) calibrating the geometric factors C and R_0 in equations 1 and 18 using a sample of known dielectric constant;

f) vibrating the sample so as to vary the gap distance, g, between the tip and the sample, wherein the vibration amplitude is small such as that caused by a piezo-electric element and wherein the frequency of vibration is within the frequency difference of element c) above;

g) measuring an averaged shift in resonant frequency and a first harmonic intensity;

h) solving equations 43 and 44 for g; the dielectric constant and the loss tangent;

i) calculating the change in gap distance required to return the gap distance to g_p;

j) electromechanically adjusting the distance between the probe tip and the sample being scanned to equal g_p; and

k) repeating steps e) through g) at a set interval period until the scanning process is complete.